

WHAT IS CLAIMED IS:

1. A thimble-type steam injection humidifier in a high response humidification system, the steam injection humidifier comprising:

a number of humidifying tubes structured of multi-passage modules, whereby flexibility of application can be enhanced according to humidifying capacity required for the high response humidification system;

10 headers arranged upstream and downstream of the humidifying  
tubes; and

detachable fastening means for fastening the humidifying tubes with the upstream and downstream headers, whereby the passages can be opened/shut according to humidifying capacity.

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2. The steam injection humidifier according to claim 1, further comprising humidifying nozzles uniformly arranged in an air flowing duct, wherein the humidifying tubes are formed to have a geometric sectional shape selected from a group including flat tube, ellipse and diamond to reduce resistance against an air flow.

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3. The steam injection humidifier according to claim 2, wherein the humidifying nozzles are uniformly arranged in the

section of the air flowing duct, and wherein the humidifying  
nozzles in one of the humidifying tubes alternate with the  
humidifying nozzles in the adjacent one of the humidifying tubes,  
whereby steam is uniformly injected to an ambient air flowing  
5 section and finely mixed.

4. The steam injection humidifier according to claim 2,  
wherein each of the humidifying nozzles has a hole which is tapered  
at an angle  $\beta$  of  $-60^\circ$  to  $+60^\circ$ .

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5. The steam injection humidifier according to claim 2,  
wherein each of the injection nozzles in each of the humidifying  
tubes is provided as a pressed pin type nozzle that is made through  
elasto-plastic deformation, or a screw type nozzle having a hole  
15 formed in a round-head plus screw.

6. The steam injection humidifier according to claim 2,  
wherein each of the humidifying nozzles is inwardly projected into  
each of the humidifying tubes so that condensate is downwardly  
20 exhausted to prevent condensate from being injected while being  
mixed with steam even if condensate is generated as steam is cooled  
by the ambient air.

7. The steam injection humidifier according to claim 2,

wherein each of the humidifying tubes comprises a pneumatic resistance adjustment tube projected to the upstream and downstream headers to allow adjustment of steam capacity introduced to the each humidifying tube, and wherein the each  
5 humidifying tube is rotatable to adjust the direction of injecting steam and the number of humidifying holes of the humidifying nozzles.

8. The steam injection humidifier according to claim 7,  
10 wherein the humidifying nozzles in the each humidifying tube can be detached and replaced with sealing bodies to allow adjustment of the number of the humidifying holes.

9. The steam injection humidifier according to claim 7,  
15 wherein one of the pneumatic resistance adjustment tubes of the each humidifying tube projected to the upstream header has variable penetrating depth into the upstream header to adjust pneumatic resistance to the each humidifying tube from the upstream header to the each humidifying tube for the uniform  
20 distribution of flow rate, and tapered in the upper part, whereby flowing rate of steam into the each humidifying tube at the inlet side can be adjusted by the rotation of the tapered surface.

10. The steam injection humidifier according to claim 9,

wherein the tapered upper surface of the one pneumatic resistance adjustment tube has an angle  $\beta$  of  $-60^\circ$  to  $+60^\circ$  .

11. The steam injection humidifier according to claim 1,  
5 wherein each of the humidifying tubes has one end coupled with the downstream header and perpendicularly formed where a support baffle plate and an opening adjustment plate are inserted for easy adjustment of condensate and steam exhaust, and the support baffle plate perforated with a number of holes and the opening adjustment  
10 plate are combined to adjust rate of steam injected by pressure drop.

12. The steam injection humidifier according to claim 1,  
wherein each of the fastening means for each of humidifying tubes  
15 and the upstream header includes:

a pneumatic resistance adjustment tube having threads formed in its lower periphery and an radially tapered portion formed at its lower end;

a ferrule; and

20 a nut fitted around the each humidifying tube for fixing the each humidifying tube,

wherein the pneumatic resistance adjustment tube is coupled with the upstream header through welding, the each humidifying tube is inserted into the pneumatic resistance adjustment tube,

the ferrule is coupled and sealed with the tapered portion of the pneumatic resistance adjustment tube, and the humidifying tube fixing nut is screwed into the threads of the pneumatic resistance adjustment tube to fasten the each humidifying tube into the upstream header.

13. The steam injection humidifier according to claim 1, wherein each of the fastening means for each of humidifying tubes and the upstream header includes:

- 10        internal threads provided in the upstream header;
  - a first nut for surrounding and fixedly supporting a pneumatic resistance adjustment tube, the first nut having upper and lower nut sections with external threads, a fixing threshold in the periphery of a middle portion, a hole with threads for
  - 15        receiving a headless bolt for one-point support, and a radially tapered lower end;
  - a ferrule for being coupled with the tapered lower end of the first nut; and
  - a second nut for fixing the each humidifying tube,
  - 20        wherein the first nut is inserted into the internal threads of the upstream header, the each humidifying tube is inserted into the lower part of the first nut, and the second nut is coupled to fasten the each humidifying tube into the upstream header.

14. The steam injection humidifier according to claim 1, wherein each of the fastening means of each of humidifying tubes and the upstream header includes:

internal threads provided in the upstream header;

5 a first nut for surrounding and fixedly supporting a pneumatic resistance adjustment tube, the first nut having external threads at the upper end, a fixing threshold in the periphery under the threads, a hole with threads for receiving a headless bolt for one-point support, and a radially tapered  
10 lower end;

a ferrule for being coupled with the tapered lower end of the first nut;

a second nut for fixing the each humidifying tube; and

a connector tube having an outer diameter the same as the  
15 each humidifying tube and the pneumatic resistance adjustment tube,

wherein the first nut is inserted into the internal threads of the upstream header, the connector tube is coupled with the lower part of the first nut to connect the each humidifying tube  
20 and the pneumatic resistance adjustment tube, and the connector tube is coupled with the second nut to fasten the each humidifying tube into the upstream header.

15. The steam injection humidifier according to claim 1,  
25 wherein each of the fastening means for each of humidifying tubes

and the upstream header includes:

internal threads provided in the upstream header;

a first nut for surrounding and fixedly supporting a  
pneumatic resistance adjustment tube, the first nut having  
5 external threads provided in the whole periphery, grooves at both  
sides of a middle portion, a hole with threads for receiving a  
headless bolt for one-point support, and a radially tapered lower  
end;

a second nut for fixing the first nut;

10 a ferrule for being coupled with the tapered lower end of  
the first nut; and

a third nut for fixing the each humidifying tube,

wherein the first nut is inserted into the internal threads  
of the upstream header, the second nut fixes the first nut to the  
15 upstream header, the each humidifying tube is inserted into the  
lower part of the first nut, and the third nut is coupled to fasten  
the each humidifying tube into the upstream header.

16. The steam injection humidifier according to claim 1,  
20 wherein each of the fastening means for each of humidifying tubes  
and the downstream header includes:

internal threads provided in the downstream header;

a support baffle plate;

an opening adjustment plate;

25 a first nut for fixing the support baffle plate and the

opening adjustment plate, the first nut having external threads at both ends and a middle portion with reduced inside radius for stopping the each humidifying tube, the support baffle and the opening adjustment plate; and

5 a second nut for fixing a pneumatic resistance adjustment tube,

wherein the first nut is coupled into the threads of the downstream header, the baffle plate, the opening adjustment plate and the humidifying tube are inserted into the first nut, and the  
10 second nut is coupled around the first nut to fasten the each humidifying tube to the downstream header.

17. The steam injection humidifier according to claim 1, further comprising cylindrical plugs for coupling the humidifying  
15 tubes with the upstream and downstream headers to adjust the number of the humidifying tubes in opening/shutting the passages according to required humidifying capacity.

18. The steam injection humidifier according to claim 1,  
20 wherein said humidifying tubes are thimble-type humidifying tubes each having passages therein for allowing steam to make a detour.

19. The steam injection humidifier according to claim 18, wherein each of said thimble-type humidifying tubes has a



passage-guiding insert having a U-shaped side section or an inside passage-guiding insert having an O-shaped side section within the each thimble-type humidifying tube to form passages so that nonuniformity of a steam state within the each thimble-type humidifying tube is compensated due to cooling by the ambient air to allow the steam state to be substantially uniform.

20. The steam injection humidifier according to claim 18, wherein each of said thimble-type humidifying tube has an outer tube, said outer tube generally having a geometric sectional shape selected from a group including a flat shape, ellipse or diamond to reduce resistance against an outer main flow, said outer tube additionally having circularly sectional end shapes where said thimble-type humidifying tubes are fastened to the upstream and downstream headers by ferrules for preventing leakage.

21. The steam injection humidifier according to claim 18, wherein each of said thimble-type humidifying tube has an inner passage-guiding insert formed to be outwardly projected in part and humidifying nozzles provided at one side of said inner passage-guiding insert.

~~22.~~ A quick response steam generator, comprising:  
a housing for defining the contour of the steam generator

to feed steam to a humidifier and storing water in the lower part;

a heater for heating water;

a spray nozzle for supplying water;

a water drain for exhausting water in the lower part of the  
5 housing;

a number of absorbers for surrounding the heater, the  
absorbers being selected from a group including a porous metal  
structure, a metal mesh and a metal fin, whereby liquid is pumped  
by capillarity to constantly maintain the upper part of the porous  
10 metal structure in a wet state, and the heat transfer area per  
unit volume between the heater and liquid is enlarged; and

a number of gaps arranged in a longitudinal direction for  
enhancing efficiency of transferring heat from the heater to  
enhance responsiveness so that bubbles generated by the heater  
15 can be easily released.